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(54) **HIGH SEAM STRENGTH ARCHITECTURAL FABRIC**

BAUMATERIAL MIT HOHER NAHTSTÄRKE

TISSU ARCHITECTURAL A COUTURES RENFORCEES

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(73) Proprietor: **W.L. Gore & Associates, Inc.**
Newark DE 19714 (US)

(72) Inventors:
- **KELMARTIN, Thomas**
  West Chester, PA 19382 (US)
- **RODRIGUEZ, Martin**
  Bear, DE 19701 (US)

(74) Representative: **Klunker . Schmitt-Nilson . Hirsch**
Patentanwälte
Destouchesstraße 68
80796 München (DE)

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Description

RELATED APPLICATIONS

[0001] This application is a continuation-in-part of U.S. Application Serial Number 11/851,695, filed September 7, 2007 (pending), which in turn is a continuation-in-part of U. S. Application Serial Number 11/195,911 filed August 2, 2005, now U. S. Patent 7,501,356 issued March 10, 2009.

FIELD OF INVENTION

[0002] The present invention relates to fabric and, more particularly, to architectural fabric that is waterproof, fire retardant, flexible, durable, and aesthetically pleasing and having exceptional seam strength.

BACKGROUND OF INVENTION

[0003] Architectural fabric is fabric used as a building structure or part of a building structure. It typically provides protection for humans from elements such as wind, sun, and rain. It may be a permanent structure or a temporary one. If temporary, it may be retractable or removable, for example by folding, rolling, or otherwise storing.

[0004] There are several requirements for architectural fabric. It must be strong enough to withstand wind and other stresses during assembly and use. It must be flexible and durable, so that it can be folded or rolled and its strength and integrity are maintained over time. It must be UV light resistant. UV light tends to degrade and weaken fabric over time. A fabric that is UV resistant will stand up under this exposure. It should generally be fire retardant and waterproof. It should be easily seamed (or "welded") and these seams must be strong, both at room temperature and extreme temperatures. It must also be aesthetically pleasing.

[0005] A known architectural fabric is a composite consisting of fiberglass fabric coated with PTFE. Although this product has certain desirable qualities, it is not suitably flexible. The fabric thus cannot be used efficiently in applications where convenient removal of the fabric is needed.

[0006] Another known architectural fabric has a coating of PVC or acrylic on polyester fabric. These products have flexibility but only limited durability. Unless specially treated, these fabrics are flammable and tend to degrade under UV light. After a certain amount of flexing and UV exposure, these products develop cracks or other imperfections that allow water to penetrate the fabric at the point where it has been compromised.

[0007] Another known architectural fabric is that disclosed in US Patent No. 6,770,577B2 to Kelmartin et al. The article disclosed therein comprises a polytetrafluoroethylene fabric attached to at least one composite membrane of a porous polytetrafluoroethylene film having a fluoropolymer adhesive (such as THV) contained in its pores. The porous polytetrafluoroethylene film is provided to make the article durable and aesthetically pleasing. Addition of the film requires additional processing, however. The film also tends to mute any pigments or colors in the fabric or the THV.

[0008] In situations where panels of fabric are welded together at elevated temperatures, seam strength is compromised when using known fabrics. Polymers such as THV may soften at elevated temperatures, thereby compromising seam strength.

[0009] An economical, weldable, waterproof, fire retardant architectural fabric with exceptional seam strength is needed in the industry.

SUMMARY OF INVENTION

[0010] The present invention provides an architectural fabric for retractable, temporary, or permanent structures having a plurality of segments, each segment including a layer of fabric having a first surface and a second surface and being made of expanded polytetrafluoroethylene fibers. The layer of fabric has a nominal warp strip tensile strength. Also included is a fluoropolymer coating disposed on at least one of the first surface and second surface and extending between and among the fibers from the respective first or second surface. At least one seam is formed by an overlap of two of the segments, the seam having a seam warp strip tensile strength that is substantially equal to the nominal warp strip tensile strength of the fabric at room temperature.

[0011] Preferably, the fluoropolymer coating is either PVDF or ETFE. When the overlap is 6.33 cm (2.5 inches), the seam warp strip tensile strength at room temperature is greater than 79.8 N/mm (456 lbf/in) (nominal warp strip tensile strength of the fabric), and at 70 degrees C, it is greater than 52.5 N/mm (300 lbf/in). The fill strip tensile strength of seam at room temperature that is preferably greater than 70.0 N/mm (400 lbf/in), and at 70 degrees C, it is greater than 35.0 N/mm (200 lbf/in).

[0012] Also preferably, the architectural fabric of the invention has a light transmission of at least 40%, and is waterproof and flame retardant, and the seam is a radio frequency or hot bar welded seam. A pigment is optionally included in said

fluoropolymer coating. The fibers of the fabric are optionally densified and may contain a filler.

[0013] In another aspect, the present invention provides a method of changing the mode of failure at ambient temperature, in the warp direction, of a seam of an architectural fabric constructed of expanded polytetrafluoroethylene fibers from fiber pullout to ultimate fabric strength by coating the fibers with a fluoropolymer coating selected from the group consisting of PVDF and ETFE.

[0014] In still another aspect, the invention provides a method of increasing seam strength at elevated temperature (70°C), of an architectural fabric made of expanded polytetrafluoroethylene fibers by a minimum of 50% and 20% in the warp and fill directions respectfully, by coating the fibers with a fluoropolymer selected from the group consisting of PVDF and ETFE.

[0015] In yet another aspect, the invention provides a method of increasing seam toughness at ambient temperature, of an architectural fabric having expanded polytetrafluoroethylene fibers by a minimum of 35% and 85% in the warp and fill directions respectfully, by coating said fibers with a fluoropolymer selected from the group consisting of PVDF and ETFE.

[0016] In a final aspect, the invention provides a method of increasing seam toughness at elevated temperature (70°C), of an architectural fabric having expanded polytetrafluoroethylene fibers by a minimum of 95% and 100% in the warp and fill directions respectfully, by coating said fibers with a fluoropolymer selected from the group consisting of PVDF and ETFE.

BRIEF DESCRIPTION OF THE DRAWING

[0017]

Figure 1 is an optical micrograph of a cross-section of an article in accordance with an exemplary embodiment of the present invention.

Figure 2 is a schematic illustration of an exemplary process for making an article according to the present invention.

Figure 3 a is a bar chart of the results of seam strip tensile testing in the warp direction.

Figure 3b is a bar chart of the results of seam strip tensile testing in the fill direction.

Figure 4 is a photograph of the inventive examples illustrating the mode of failure change using the present invention.

Figure 5 is an enlarged view of the seam of the inventive example shown in Figure 4.

Figure 6 is a graph of the warp direction toughness of the inventive examples compared to the comparative example.

Figure 7 is a graph of the fill direction toughness of the inventive examples compared to the comparative example.

DETAILED DESCRIPTION OF INVENTION

[0018] The present invention will now be described with reference to the figures in the drawing. Figure 1 is an optical micrograph of a cross-section of an article 10 according to an exemplary embodiment of the present invention. In this exemplary embodiment, article 10 is an architectural fabric. Article 10 includes a fabric 11 made of fibers 13 of a fluoropolymer material, preferably PTFE fibers that have sufficient strength for a particular application, and most preferably expanded PTFE fibers. Fabric 11 has a warp and a weft direction, accounting for the cross-sectional views perpendicular to and parallel to the axes of the individual fibers of fabric 11 shown in Figure 1.

[0019] Fabric 11 has a first surface 20 and a second surface 21. Disposed adjacent to first surface 20, which extends along fibers 13 in both the warp and weft direction, and extending in between and among fibers 13 is a fluoropolymer coating 12, preferably PVDF (most preferably a copolymer of vinylidene fluoride and hexafluoropropylene) or ETFE (most preferably a copolymer of ethylene tetrafluoroethylene).

[0020] Article 10 is useful as an architectural fabric with only first surface 20 covered by fluoropolymer coating 12. A preferable embodiment, however, also has fluoropolymer coating 12 disposed on second surface 21 (and extending between and among fibers 13 from such second surface 21).

[0021] Fabric 11 is a material that is UV light resistant and fire retardant. It must also be strong, flexible and durable. Fabric made from expanded polytetrafluoroethylene fibers is employed.

[0022] Fluoropolymer coating 12 is a material that is UV light resistant and fire retardant. PVDF and ETFE are employed. This preferred fluoropolymer coating is also advantageously flexible, adherent to the fabric 11, clear or translucent, and

provide excellent seam strength when panels of fabric are welded together.

[0023] Preferably, the coating on both sides of the fabric is the same material. The fluoropolymer can be filled for functionality, such as color, UV resistance (if needed, for example if no PTFE fabric is used), and flame resistance.

[0024] Fluoropolymer coating 12 is preferably applied to fabric 11 by extrusion coating, although other methods, such as solvent coating or lamination with or without the use of release layers are alternatives. Figure 2 depicts a preferred extrusion coating process for making the architectural fabric of this invention. Fabric 11 is passed between rolls 91 and 92 while fluoropolymer coating 12 is simultaneously extruded onto fabric 11 from extruder 90. The surfaces of rolls 91 and 92, as well as the temperature and speed of the rolls are critical processing parameters for making the present invention. Details of these parameters are given in the example below.

[0025] Surprisingly, Applicant has discovered that when panels of the article of the present invention are welded together, the seam between the panels has particularly high strength. This is true both at room temperature and elevated temperature. As a result, many different kinds of bonding techniques can be used to form the seam, such a hot bar welding and radio frequency welding.

[0026] In particular, the inventors have discovered that coating the fabric with PVDF or ETFE produces a seam that has a seam warp strip tensile strength that is substantially equal to the nominal warp strip tensile strength of the base fabric itself at room temperature. Fundamentally, the inventors have discovered that the failure mode at ambient temperature for a seam of architectural fabric can be changed from fiber pull-out (seen with conventional fabric seams) to ultimate fabric strength, by coating the base fabric with PVDF or ETFE.

[0027] Also surprisingly, article 10 can be much more easily seam-sealed to itself using welding techniques known in the art of seam-sealing for example, with PTFE/fiberglass fabrics. This is a result of the elimination of the microporous PTFE element described in US Patent No. 6,770,577B2. A variety of seaming techniques can be used. A secure seam is formed by applying heat (about 230 degrees C for 45 seconds) and pressure to overlapped portions of the inventive fabric. A suitable seam sealing device is an electric impulse hot bar welder available from Aline Heat Sealing Corporation, Cerritos CA, part number HD-25. Surprisingly, radio frequency welding can also be used, as can wedge welding and hot-air welding. Using the invention, one can easily get a strong weld without the need for special processing, or for adding additional adhesives or seam tape as with other fabrics currently used.

[0028] The following example is intended to illustrate, but not limit, the present invention.

EXAMPLES

Comparative Example 1

[0029] THV221G (Dyneon, Inc, Oakdale, MN.) which was pigmented tan was extruded using a single screw extruder and a slotted die at a temperature of 250°C. It was directed vertically downward into a nip created by two rolls; one being a TEFLON®-sleeved EPDM rubber roll and the other a TEFLON®-coated steel roll. The thickness of the extruded film was 175 micrometers. The EPDM roll had a surface temperature of 90°C, and the steel roll had a surface temperature of 115° C. The surface speed of the rolls was 2.75 meters per minute. Fabric woven of expanded PTFE fiber was obtained from W.L. Gore & Associates, Inc. This fabric was woven in a plain weave, 18 ends by 18 picks per centimeter. Each end and each pick yarn was composed of two 500 denier expanded PTFE fibers plied together. (This fabric was subjected to the strength test set forth below under the heading "Seam Strength" in the warp direction, except not on a seam, just the fabric itself, in order to establish a nominal warp strip fabric strength. The result was 79.8 N/mm (456 lbf/in).)

[0030] The fabric entered the nip over the steel roll and was pressed against the molten THV221G in the nip. The nip force was 130 Newtons per centimeter. The THV221G was pushed into the voids in the fabric by the action of the nip. The resulting THV221G/fabric composite was wound onto a roll at the end of the extrusion line.

[0031] The aforementioned THV221G/fabric composite was then run a second time on the extrusion line except that a second coating of molten THV221 G pigmented red was applied to the fabric face which was not extruded upon in the first pass. The machine conditions were the same for this second pass as they were for the first pass. This material produced in this example was identified as 360-75. The thickness of the THV221G/fabric composite was 0.65 millimeters, and the mass per unit area was 1240 grams per square meter.

Inventive Example 1

[0032] An architectural fabric was produced in a manner similar to Comparative Example 1, except that PVDF 3120-10 (Arkema Inc., Philadelphia, PA) was used instead of THV221G.

Inventive Example 2

[0033] An architectural fabric was produced in a manner similar to Comparative Example 1, except that ETFE LM-

730A (Asahi Glass Company, Downingtown, PA) was used instead of THV221G.

TESTING

[0034] The following procedures are used to test for various properties of architectural fabric.

(1) Waterproofness

Apparatus:

[0035]

RO/Distilled water
Thermometer
Low Hydrostatic Pressure Tester (Alfred Suter Co., Ramsey, NJ, Model No. 502 Suter LHPT)
Timer
Water Circulator

Test Specimens:

[0036]

Specimen size: circular sample of 4 1/2" (11.4 cm) diameter.
Specimens per sample: Three.

[0037] Conditioning: Condition the specimens at 21±1° C. (70±2° F.), 65±2% RH prior to testing.

Test Procedure:

[0038]

1. Check the water level in the tank.
2. Add water if the level is too low.
3. Turn the pump on.
4. Check that the water temperature is at 27±3° C. (80±5° F.).

    4.1 Run the motor to heat or add heated water to the tank if the water temperature is too low.
    4.2 Float an ice pack, located in the freezer, in the tank to lower the temperature if the water temperature is too high (or becomes too high while testing), or add cold water.

5. Purge the water lines.
6. Place a specimen face side down under the specimen holder.
7. Clamp the specimen in place.
8. Open the valves to start water flow.
9. Set a timer for 3 minutes.
10. Start the timer when the gauge on the LPHT tester reaches the specified pressure (0.076 bar) (1.1 psig).
11. Check each specimen for leaks. Samples that leak are reported as failures. Those that do not leak, pass.

    11.1 Failures should only be counted if leaks occur in the test area.

        11.1.1 Drops of water penetrating the specimen at the clamped edge of the specimen or within 0.32 cm (1/8") of this edge shall not be counted.

[0039] Samples of Inventive Examples 1 and 2 were tested as described above, and both samples passed with no leakage.

(2) Fire Retardance

[0040] The example fabric was tested for fire retardance as follows.

Apparatus:

Cabinet including Tirrill Burner	Brass weights
Metal specimen holder and clips	Scissors or hole punch
Specimen mounting block	Butane lighter
Timer (tenths of seconds)	Disposable gloves
Metric ruler (1 mm graduations)	Gas: methane 99% pure
Plastic bag	

Test Specimens:

[0041] Specimen size: 7.6 cm (3") × 30.4 cm (12") with the 30.4 cm (12") length parallel to the test direction. Number of samples: two.

[0042] Conditioning: Condition the specimens at 70±2° F, 65±2% RH prior to testing.

Test Procedure:

1. Cut specimens as specified above.

[0043]

1.1. Ensure that the gas pressure is 0.17±0.017 bar (2.5±0.25 psi).
1.2. Turn power on (control panel on counter).
1.3. Turn the pilot knob slightly counter-clockwise, so that it is on.
1.4. Ignite the pilot with the butane lighter.
1.5. Adjust the pilot size to 0.32 cm (1/8") using the pilot knob. Measure the pilot flame from its lowest point to the tip.
1.6. Set the flame ignition timer to 120 seconds.
1.7. Turn the flame/fan knob to flame and burn the flame for at least 2 minutes prior to the beginning of each set up and testing session.
1.9. Adjust the flame height to 38 cm (1.5") by turning the knob at the bottom of the burner clockwise to increase the height or counter clockwise to decrease the height. The tip of the flame should reach the top point of the flame indicator.
1.10. Re-set the flame ignition timer to 12 seconds and re-light the flame.
1.11. Turn the flame/fan knob to fan.
1.12. Place the metal specimen holder on the mounting block.
1.13. Align a dummy specimen in the metal holder with the short edge of the dummy aligned with the lower edge of the holder,
1.14. Close the specimen holder and clamp with the clips at two places on each side making sure the dummy is smooth and flat in the holder,
1.15. Turn the flame/fan knob to flame.
1.16. Light the flame with the butane lighter.
1.17. Immediately turn the flame/fan knob to off.
1.18. Position the specimen holder securely in the cabinet.
1.19. Make sure the holder is positioned in the groove of the holder rest at the back of the cabinet and the middle of the lower edge of the specimen is centered 1.9 cm (3/4") above the burner,
1.20. Close the cabinet door and the hood sash.
Note: The specimen must be tested within 2 minutes of being placed in the cabinet.
1.21. Turn the flame/fan knob to flame to start the 12-second flame.
1.22. Once the 12-second flame has extinguished confirm that the pilot light is the proper size.
1.23. Depress the door release button and allow the cabinet to ventilate for 30 seconds or until all smoke and fumes are removed.
1.24. Adjust the pilot light, if necessary, and repeat steps 1.15 through 1.24 as needed until proper pilot size is maintained.

2. Testing:

[0044]

2.1. Place the metal specimen holder on the mounting block.
2.2. Align the specimen in the metal holder such that the test area does not contain any identification markings when the short edge of the specimen is aligned with the lower edge of the holder.
2.3. Close the specimen holder and clamp with clips at two places on each side making sure the specimen is smooth and flat in the holder,
2.4. Turn the flame/fan knob to flame.
2.5. Light the flame with the butane lighter,
2.6. Immediately turn the flame/fan knob to off.
2.7. Position the specimen holder securely in the cabinet.
2.8. Make sure that the holder is positioned in the groove of the holder rest at the back of the cabinet and that the middle of the lower edge of the specimen is centered 1.9 cm (3/4") above the burner.
2.9. Close the cabinet door and the hood.
Note: The specimens must be tested within 2 minutes of being place in the cabinet.
2.10. Turn the flame/fan knob to flame to start the 12-second flame.
2.11. Determine the after-flame, and after-glow time, and the presence of melting or dripping, after the 12-second flame extinguishes, and record in the lab database.
2.11.1. After-flame: Using the timer mounted on the hood, measure the number of seconds, to the nearest 0.1 seconds, that the material continues to burn after the igniting flame extinguishes. Do not turn the fan on until the specimen has stopped glowing, regardless of whether or not the after-glow is being measured.
2.11.2. After-glow: Using the automatic timer, measure the number of seconds, to the nearest 0.1 seconds, that the material glows after the flaming ends. The glow shall not be extinguished even if after-glow time is not being evaluated because of the glow's effect on char length.
2.11.3. Melt/Drip: Look for signs of melting or dripping.

(3) Seam Strength

[0045] Two pieces of the example fabric were placed in overlapping relationship in the warp direction, such that 2.5 inches (6.35 cm) of each piece overlapped. No seam tape was used, nor was any scuffing or abrasion performed on the areas to be welded. The overlap was welded to form a seam. For Comparative Example 1 and Inventive Example 1, the seam was radio frequency welded using a Thermatron device, power setting 1066, preheated to 125 degrees F, for 6 seconds preweld, 6 seconds weld, 6 seconds cool down. For Inventive Example 2, the seam was hot bar welded using an Aline Welder Model HD-25 on both sides at 260 degrees C for 30 seconds at 1.03 bar (15 psi). Strips of the fabric were cut 2.5 inches (6.35 cm) wide by 14 inches (35.5 cm) long with the long direction perpendicular to the seam. The seam strength was tested by pulling the seam on a tensile tester (Instron Corporation, Norwood Mass., Model 5567) with 4 inch (10.16 cm) gauge length at 2 inches (5.08 cm) per minute extension rate. Five such specimens were produced. The results are tabulated below, and indicate a very strong seam was produced using this simple welding technique on the inventive fabric. A seam having a strength of at least 90% of the nominal strength of the fabric is desired.

[0046] Comparative Example 1 and Inventive Examples 1 and 2 were all tested for seam strength in both the warp and fill directions. These tests were done both at room temperature and at 70 degrees C. As shown in FIG. 3a, the warp seam strip tensile strength of PVDF (Inventive Example 1) was 100 N/mm (573 lbf/in) at room temperature, which is 8% higher than the THV (Comparative Example 1), which was 92.6 N/mm (529 lbf/in). Also at room temperature, the ETFE (Inventive Example 2) had a warp strip tensile strength of 99.0 N/mm (566 lbf/in), 7% higher than the Comparative Example 1.

[0047] At elevated temperature of 70 degrees C, PVDF (Inventive Example 1 had a warp strip seam tensile strength of 56.0 N/mm (320 lbf/in), 55% higher than Comparative Example 1, which was 36.0 N/mm (206 lbf/in). Similarly ETFE (Inventive Example 2) had a warp strip seam tensile strength of 59.9 N/mm (342 lbf/in), 66% higher than the Comparative Example 1.

[0048] Surprisingly, the inventors also discovered, as illustrated in FIGS. 4 and 5, that these seam strength tests indicate a change in the mode of failure of the seams from fiber pullout (with Comparative Example 1) to ultimate fabric strength (with the Inventive Examples). Specifically, FIGS. 4 and 5 show that for the Inventive Examples, the strength tests resulted in tears 50 of the fabric itself, not the seam 51. This is quite surprising.

[0049] FIG. 3b illustrates the results of the seam strength testing in the fill direction. Specifically, the fill seam strip tensile strength of PVDF (Inventive Example 1) was 83.8 N/mm (479 lbf/in) at room temperature, which is 25% higher than the THV (Comparative Example 1), which was 67.2 N/mm (384 lbf/in). Also at room temperature, the ETFE (Inventive

Example 2) had a fill strip tensile strength of 75.4 N/ mm (431 lbf/in), 12% higher than the Comparative Example 1.

[0050] At elevated temperature of 70 degrees C., PVDF (Inventive Example 1 had a fill strip seam tensile strength of 41.3 N/mm (236 lbf/in), 38% higher than Comparative Example 1, which was 29.9 N/mm (171 lbf/in). Similarly ETFE (Inventive Example 2) had a fill strip seam tensile strength of 36.2 N/mm (207 lbf/in), 21% higher than the Comparative Example 1.

[0051] These data indicate that using the fluoropolymer coating of the present invention considerably increases seam strength, particularly at elevated temperatures, over conventional coatings. This enables seaming and processing at higher temperatures without compromising the fabric. This is a significant advance in the art of architectural fabrics.

(4) Toughness

[0052] Toughness was measured according to the formula and method set forth in U.S. Pat. No. 6,071,452.

[0053] Toughness measurements were made on Comparative Example 1 (THV) and both Inventive Examples (PVDF and ETFE) at room temperature and elevated temperature of 70 degrees C. The data are shown in FIGS. 6 (for the warp direction toughness) and 7 (for the fill direction toughness). As can be seen, the present invention improves toughness in the warp and fill directions by 35% and 85%, respectively.

[0054] The table below summarizes the warp direction strength and toughness data.

6.35 cm (2.5") OVERLAP SEAM - WARP DIRECTION				
	SEAM STRENGTH, N/mm (lb/in)		TOUGHNESS, bar (psi)	
POLYMER	ROOM TEMP	70°C	ROOM TEMP	70°C
THV	92.6 (529)	36.1 (206)	195.9 (2840)	76.34 (1107)
PVDF	100 (573)	56.0 (320)	263.9 (3827)	150.5 (2182)
ETFE	99.1 (566)	59.9 (342)	326.8 (4739)	168.9 (2449)

[0055] The table below summarizes the fill direction strength and toughness data.

6.35 cm (2.5") OVERLAP SEAM - FILL DIRECTION				
	SEAM STRENGTH, N/mm (lb/in)		TOUGHNESS, bar (psi)	
POLYMER	ROOM TEMP	70°C	ROOM TEMP	70°C
THV	67.2 (384)	29.9 (171)	85.31 (1237)	29.1 (423)
PVDF	83.8 (479)	41.3 (236)	195.4 (2833)	60.2 (873)
ETFE	75.4 (431)	36.2 (207)	159.7 (2315)	65.4 (948)

[0056] While particular embodiments of the present invention have been illustrated and described herein, the present invention should not be limited to such illustrations and descriptions. It should be apparent that the changes and modifications may be incorporated and embodied as part of the present invention within the scope of the following claims.

Claims

1. An architectural fabric for retractable, temporary, or permanent structures comprising:

a. a plurality of segments, each segment comprising:

i. a layer of fabric having a first surface and a second surface and comprising expanded polytetrafluoroethylene fibers, said layer of fabric having a nominal warp strip tensile strength; and

ii. a fluoropolymer coating disposed on at least one of said first surface and said second surface and extending between and among said fibers from said respective first or second surface; and

b. at least one seam formed by an overlap of two of said segments, said seam having a seam warp strip tensile strength that is substantially equal to said nominal warp strip tensile strength at room temperature; and

wherein said fluoropolymer coating comprises PVDF or EFTE.

2. An architectural fabric as defined in claim 1 wherein said overlap is 6.35 cm (2.5 inches) and said seam warp strip tensile strength at room temperature is greater than 79.8 N/mm (456 lbf/in).

3. An architectural fabric as defined in claim 1 wherein said overlap is 6.35 cm (2.5 inches) and said seam warp strip tensile strength at 70 degrees C is greater than 52.5 N/mm (300 lbf/in).

4. An architectural fabric as defined in claim 1 wherein said overlap is 6.35 cm (2.5 inches) and said seam has a fill strip tensile strength at room temperature that is greater than 70.0 N/mm (400 lbf/in).

5. An architectural fabric as defined in claim 1 wherein said overlap is 6.35 cm (2.5 inches) and said seam has a fill strip tensile strength at 70 degrees C that is greater than 35.0 N/mm (200 lbf/in).

6. An architectural fabric as defined in claim 1 wherein:

(a) said architectural fabric has a light transmission of at least 40%, and is waterproof and fame retardant, or
(b) said seam is a radio frequency or hot bar welded seam, or
(c) said fibers are desilfied; or
(d) said fibers further comprise a filler.

7. An architectural fabric as defined in claim 1 further comprising a pigment in said fluoropolymer coating.

8. A method of providing an architectural fabric, comprising:

providing a plurality of segments, each segment comprising a layer of fabric comprising expanded polytetrafluoroethylene fibers, said layers of fabric having a nominal warp strip tensile strength;
coating fibers of each segment with a fluoropolymer coating, wherein said fluropolymer coating comprises PVDF or ETFE; and
forming at least one seam at an overlap of two segments of the fabric.

9. The method according to claim 8, wherein each layer of fabric has a first surface and a second surface, and wherein the fluoropolymer coating is disposed on at least one of said first surface and said second surface and extends between and among said fibers from said respective first or second surface, and optionally wherein the coating is applied to the fabric by extrusion coating.

10. The method according to claim 8 or 9, wherein said formed seam has a seam warp strip tensile strength that is substantially equal to said nominal warp strip tensile strength at room temperature, and optionally where the segments are welded together to form the seam.

11. The method according to claim 8, 9 or 10, wherein providing the coating changes the mode of failure at ambient temperature in a warp direction of the seam of the architectural fabric from fiber pullout to ultimate fabric strength.

12. The method according to claim 8, 9 or 10, wherein providing the coating increases the seam strength at an elevated temperature of 70°C of the architectural fabric by a minimum of 50% and 20% in warp and fill directions respectively.

13. The method according to claim 8, 9 or 10, wherein providing the coating increases the seam toughness at ambient temperature of the architectural fabric by a minimum of 35% and 85% in warp and fill directions respectively.

14. The method according to claim 8, 9 or 10, wherein providing the coating increases the seam toughness at an elevated temperature 70°C of the architectural fabric comprising expanded polytetrafluoroethylene fibers by a minimum of 95% and 100% in warp and fill directions respectively.

Patentansprüche

1. Architekturgewebe für einfahrbare, temporäre oder permanente Strukturen, aufweisend:

a) eine Mehrzahl von Segmenten, wobei jedes Segment aufweist:

i. eine Gewebeschicht mit einer ersten Oberfläche und einer zweiten Oberfläche sowie mit expandierten Polytetrafluorethylen-Fasern, wobei die Gewebeschicht eine nominale Kettstreifen-Zugfestigkeit aufweist; und
ii. eine Fluorpolymerbeschichtung, die auf mindestens einer von der ersten Oberfläche und der zweiten Oberfläche angeordnet ist und sich zwischen sowie unter den Fasern von der jeweiligen ersten oder zweiten Oberfläche weg erstreckt; und

b. mindestens eine Naht, die durch eine Überlappung von zwei der Segmente gebildet ist, wobei die Naht eine Naht-Kettstreifen-Zugfestigkeit aufweist, die im Wesentlichen gleich der nominalen Kettstreifen-Zugfestigkeit bei Raumtemperatur ist; und

wobei die Fluorpolymerbeschichtung PVDF oder EFTE aufweist.

2. Architekturgewebe nach Anspruch 1,
wobei die Überlappung 6,35 cm (2,5 Inch) beträgt und die Naht-Kettstreifen-Zugfestigkeit bei Raumtemperatur größer ist als 79,8 N/mm (456 lbf/in).

3. Architekturgewebe nach Anspruch 1,
wobei die Überlappung 6,35 cm (2,5 Inch) beträgt und die Naht-Kettstreifen-Zugfestigkeit bei 70 °C größer ist als 52,5 N/mm (300 lbf/in).

4. Architekturgewebe nach Anspruch 1,
wobei die Überlappung 6,35 cm (2,5 Inch) beträgt und die Naht eine Füllstreifen-Zugfestigkeit bei Raumtemperatur aufweist, die größer als 70,0 N/mm (400 lbf/in) ist.

5. Architekturgewebe nach Anspruch 1,
wobei die Überlappung 6,35 cm (2,5 Inch) beträgt und die Naht eine Füllstreifen-Zugfestigkeit bei 70 °C aufweist, die größer als 35,0 N/mm (200 lbf/in) ist.

6. Architekturgewebe nach Anspruch 1, wobei:

(a) das Architekturgewebe eine Lichtdurchlässigkeit von mindestens 40 % aufweist und wasserdicht und flammhemmend ist, oder
(b) die Naht eine durch Hochfrequenz- oder Heißstab-Schweißen gebildete Naht ist, oder
(c) die Fasern verdichtet sind; oder
(d) die Fasern ferner einen Füllstoff aufweisen.

7. Architekturgewebe nach Anspruch 1,
das ferner ein Pigment in der Fluorpolymerbeschichtung aufweist.

8. Verfahren zum Bereitstellen eines Architekturgewebes,
das folgende Schritte aufweist:

Bereitstellen einer Mehrzahl von Segmenten, wobei jedes Segment eine Gewebeschicht mit expandierten Polytetrafluorethylen-Fasern aufweist, wobei die Gewebeschichten eine nominale Kettstreifen-Zugfestigkeit aufweisen;
Beschichten von Fasern von jedem Segment mit einer Fluorpolymerbeschichtung, wobei die Fluorpolymerbeschichtung PVDF oder ETFE aufweist; und
Bilden von mindestens einer Naht an einer Überlappung von zwei Segmenten des Gewebes.

9. Verfahren nach Anspruch 8,
wobei jede Gewebeschicht eine erste Oberfläche und eine zweite Oberfläche aufweist, und wobei die Fluorpolymerbeschichtung auf mindestens einer von der ersten Oberfläche und der zweiten Oberfläche angeordnet wird und sich zwischen sowie unter den Fasern von der jeweiligen ersten oder zweiten Oberfläche weg erstreckt, und wobei optional die Beschichtung auf das Gewebe durch Extrusionbeschichtung aufgebracht wird.

10. Verfahren nach Anspruch 8 oder 9,
wobei die gebildete Naht eine Naht-Kettstreifen-Zugfestigkeit aufweist, die im Wesentlichen gleich der nominalen Kettstreifen-Zugfestigkeit bei Raumtemperatur ist, und wobei optional die Segmente zum Bilden der Naht miteinander verschweißt werden.

11. Verfahren nach Anspruch 8, 9 oder 10,
wobei das Bereitstellen der Beschichtung die Art des Versagens bei Umgebungstemperatur in Kettrichtung der Naht des Architekturgewebes von Faserauszug bis zur letztendlichen Gewebefestigkeit ändert.

12. Verfahren nach Anspruch 8, 9 oder 10,
wobei das Bereitstellen der Beschichtung die Nahtfestigkeit bei einer erhöhten Temperatur von 70 °C des Architekturgewebes in Kettrichtung und Füllrichtung um mindestens 50 % bzw. 20 % erhöht.

13. Verfahren nach Anspruch 8, 9 oder 10,
wobei das Bereitstellen der Beschichtung die Nahtzähigkeit bei Umgebungstemperatur des Architekturgewebes in Kettrichtung und Füllrichtung um mindestens 35 % bzw. 85 % erhöht.

14. Verfahren nach Anspruch 8, 9 oder 10,
wobei das Bereitstellen der Beschichtung die Nahtzähigkeit bei einer erhöhten Temperatur von 70 °C des expandierte Polytetrafluorethylen-Fasern aufweisenden Architekturgewebes in Kettrichtung und Füllrichtung um mindestens 95 % bzw. 100 % erhöht.

Revendications

1. Tissu pour architecture destiné à des structures rétractables temporaires ou permanentes, comprenant :

a. plusieurs segments, chaque segment comprenant :

i. une couche de tissu possédant une première surface et une deuxième surface et comprenant des fibres en polytétrafluoréthylène expansé, ladite couche de tissu possédant une résistance nominale à la traction au niveau d'une bande de fils de chaîne ; et
ii. un revêtement en fluoropolymère disposé sur au moins une desdites surfaces choisie parmi ladite première surface et ladite deuxième surface et s'étendant entre lesdites fibres et parmi ces dernières à partir de ladite première ou de ladite deuxième surface respective ; et

b. au moins une couture que l'on obtient via un chevauchement de deux desdits segments, ladite couture possédant une résistance à la traction au niveau de la bande de fils de chaîne à l'endroit de la couture, qui est essentiellement égale à ladite résistance nominale à la traction au niveau de la bande de fils de chaîne à la température ambiante ; et

dans lequel ledit revêtement en fluoropolymère comprend du PVDF ou du EFTE.

2. Tissu pour architecture tel que défini à la revendication 1, dans lequel ledit chevauchement s'élève à 6,35 cm (2,5 pouces) et ladite résistance à la traction au niveau de la bande de fils de chaîne à l'endroit de la couture à la température ambiante est supérieure à 79,8 N/mm (456 livres/pouce).

3. Tissu pour architecture tel que défini à la revendication 1, dans lequel ledit chevauchement s'élève à 6,35 cm (2,5 pouces) et ladite résistance à la traction au niveau de la bande de fils de chaîne à l'endroit de la couture à 70 °C est supérieure à 52,5 N/mm (300 livres/pouce).

4. Tissu pour architecture tel que défini à la revendication 1, dans lequel ledit chevauchement s'élève à 6,35 cm (2,5 pouces) et ladite couture possède une résistance à la traction au niveau d'une bande de fils de trame à la température ambiante qui est supérieure à 70,0 N/mm (400 livres/pouce).

5. Tissu pour architecture tel que défini à la revendication 1, dans lequel ledit chevauchement s'élève à 6,35 cm (2,5 pouces) et ladite couture possède une résistance à la traction au niveau d'une bande de fils de trame à 70 °C qui est supérieure à 35,0 N/mm (200 livres/pouce).

6. Tissu pour architecture tel que défini à la revendication 1, dans lequel :

(a) ledit tissu pour architecture possède une transmission de la lumière d'au moins 40 %, et est imperméable et difficilement combustible ; ou
(b) ladite couture représente une couture que l'on obtient via un soudage par énergie radioélectrique ou un soudage via des barres chauffantes ; ou
(c) lesdites fibres sont densifiées ; ou
(d) lesdites fibres comprennent en outre une matière de charge.

7. Tissu pour architecture tel que défini à la revendication 1, comprenant en outre un pigment dans ledit revêtement en fluoropolymère.

8. Procédé pour procurer un tissu pour architecture, comprenant le fait de :

procurer plusieurs segments, chaque segment comprenant une couche de tissu comprenant des fibres en polytétrafluoréthylène expansé, lesdites couches de tissu possédant une résistance nominale à la traction au niveau d'une bande de fils de chaîne ;
recouvrir des fibres de chaque segment avec un revêtement en fluoropolymère, ledit revêtement en fluoropolymère comprenant du PVDF ou du ETFE ; et
réaliser au moins une couture à un chevauchement de deux segments du tissu.

9. Procédé selon la revendication 8, dans lequel chaque couche de tissu possède une première surface et une deuxième surface, et dans lequel le revêtement en fluoropolymère est disposé sur au moins une desdites surfaces choisie parmi ladite première surface et ladite deuxième surface et s'étend entre lesdites fibres et parmi ces dernières à partir de ladite première ou deuxième surface respective, et de manière facultative dans lequel on applique le revêtement sur le tissu via une enduction par extrusion.

10. Procédé selon la revendication 8 ou 9, dans lequel ladite couture que l'on obtient possède une résistance à la traction au niveau de la bande de fils de chaîne à l'endroit de la couture, qui est essentiellement égale à ladite résistance nominale à la traction au niveau de la bande de fils de chaîne à la température ambiante, et de manière facultative, dans lequel les segments sont soudés les uns aux autres pour obtenir la couture.

11. Procédé selon la revendication 8, 9 ou 10, dans lequel l'application du revêtement modifie le mode de défaillance à la température ambiante dans la direction de chaîne de la couture du tissu pour architecture en le faisant passer d'une résistance à l'arrachement des fibres à une résistance ultime du tissu à la traction.

12. Procédé selon la revendication 8, 9 ou 10, dans lequel l'application du revêtement augmente la résistance de la couture à une température élevée de 70 °C du tissu pour architecture, à concurrence d'un minimum de 50 % et de 20 % dans les directions de chaîne et de trame, respectivement.

13. Procédé selon la revendication 8, 9 ou 10, dans lequel l'application du revêtement augmente la ténacité de la couture à la température ambiante du tissu pour architecture, à concurrence d'un minimum de 35 % et de 85 % dans les directions de chaîne et de trame, respectivement.

14. Procédé selon la revendication 8, 9 ou 10, dans lequel l'application du revêtement augmente la ténacité de la couture à une température élevée de 70 °C du tissu pour architecture comprenant des fibres en polytétrafluoréthylène expansé, à concurrence d'un minimum de 95 % et de 100 % dans les directions de chaîne et de trame, respectivement.

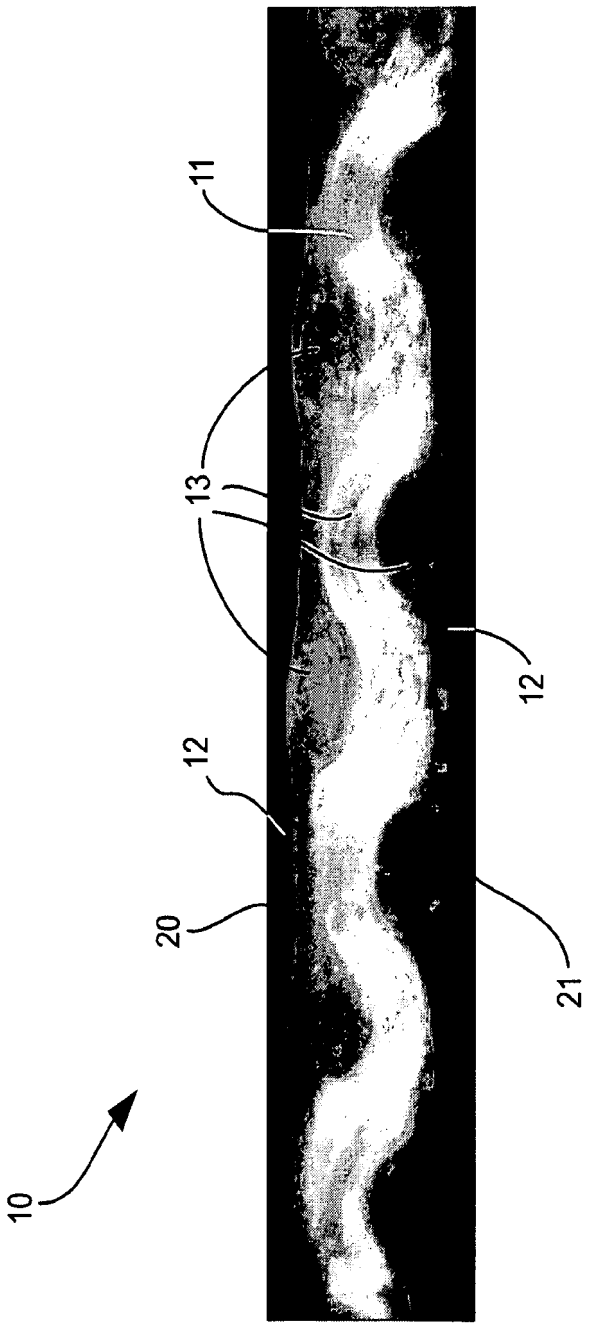


FIG. 1

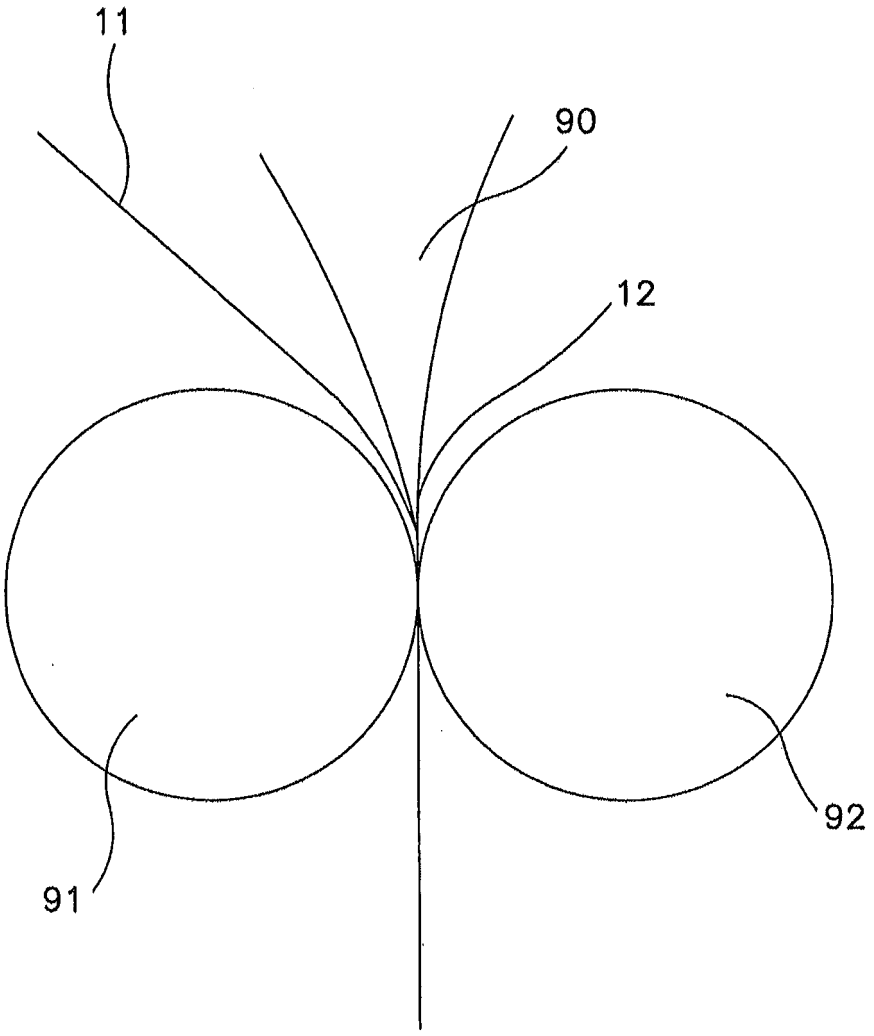


FIG. 2

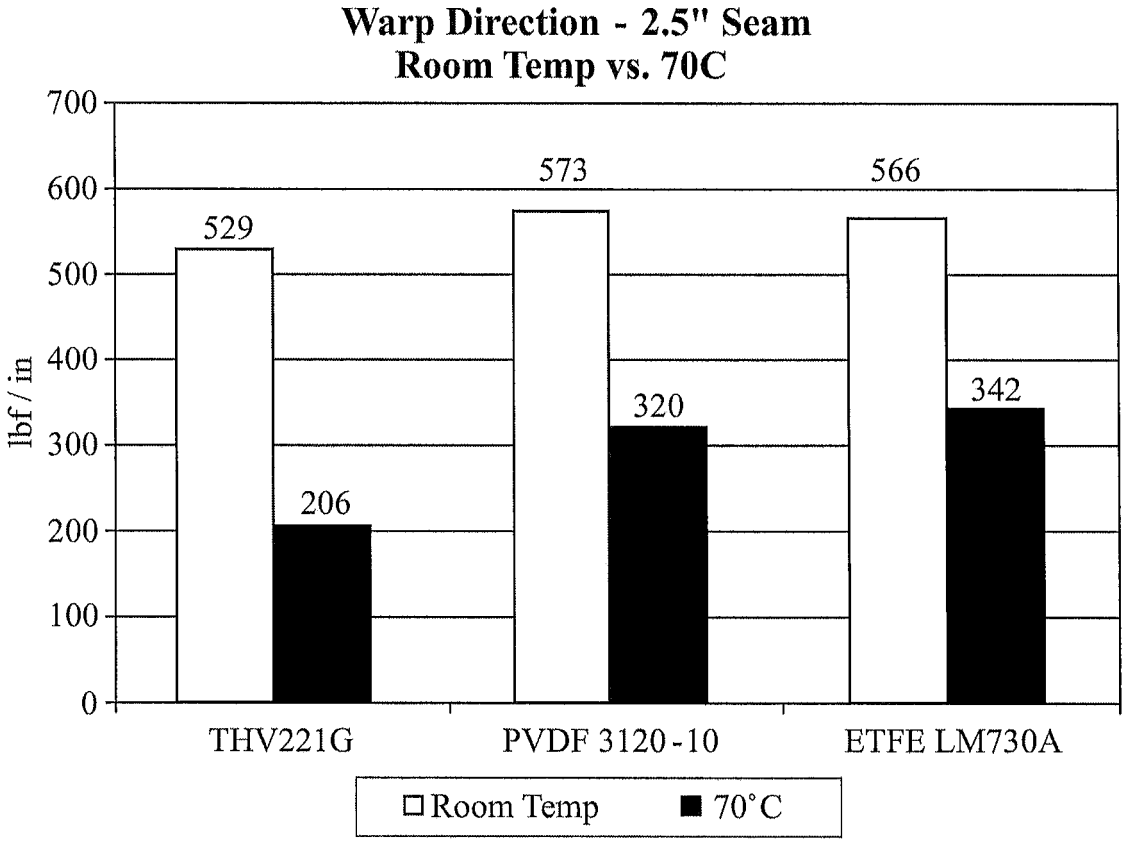

Warp Direction - 2.5" Seam
Room Temp vs. 70C
lbf / in
700
600
500
400
300
200
100
0
529
206
573
320
566
342
THV221G
PVDF 3120-10
ETFE LM730A
Room Temp
70°C

FIG. 3a

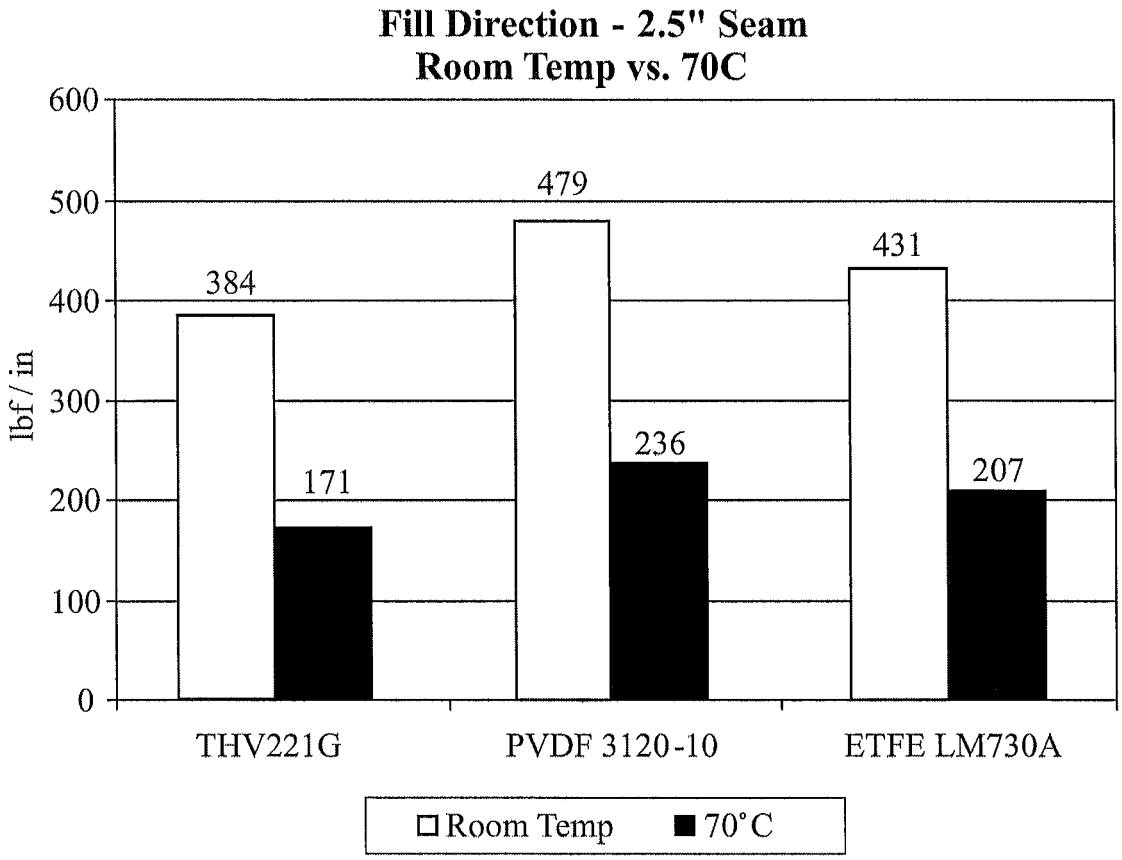

Fill Direction - 2.5" Seam
Room Temp vs. 70C
lbf / in
600
500
400
300
200
100
0
384
171
479
236
431
207
THV221G
PVDF 3120-10
ETFE LM730A
Room Temp
70°C

FIG. 3b

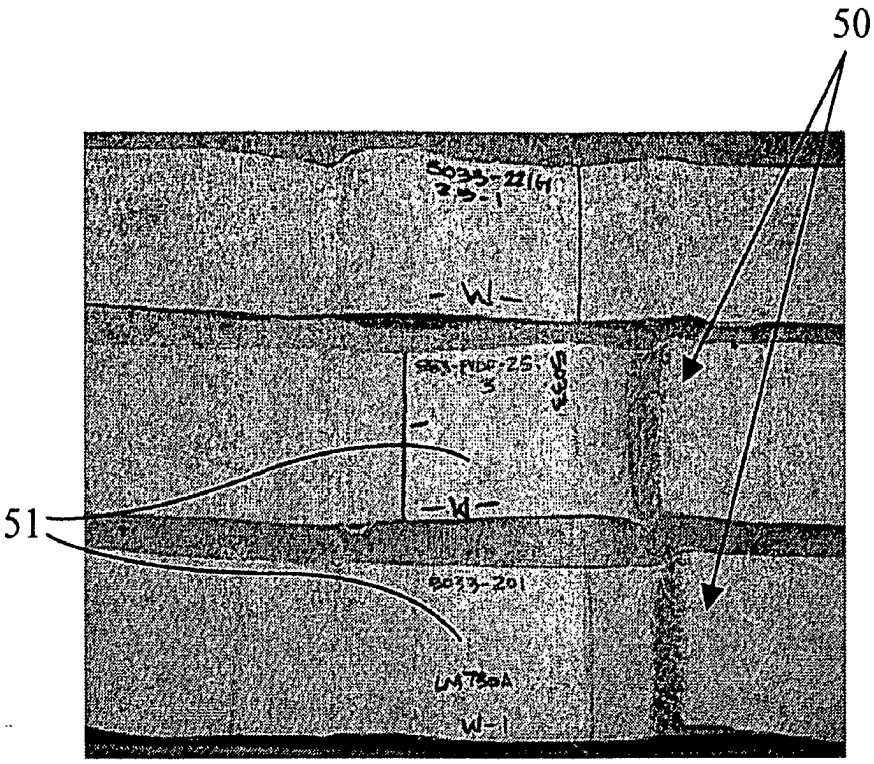


FIG. 4

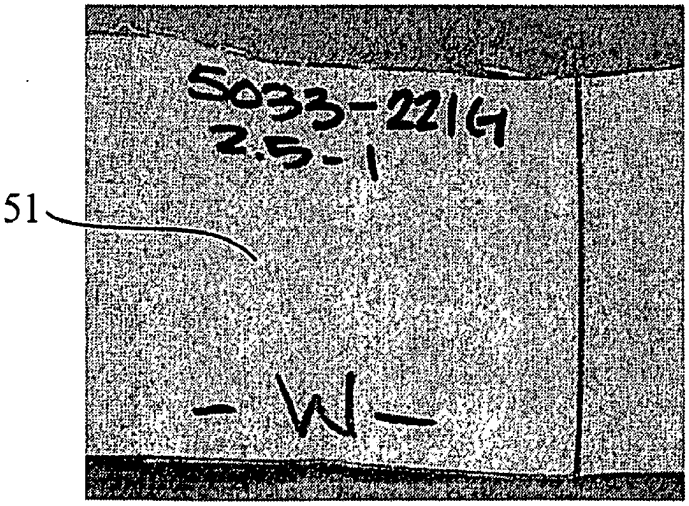


FIG. 5

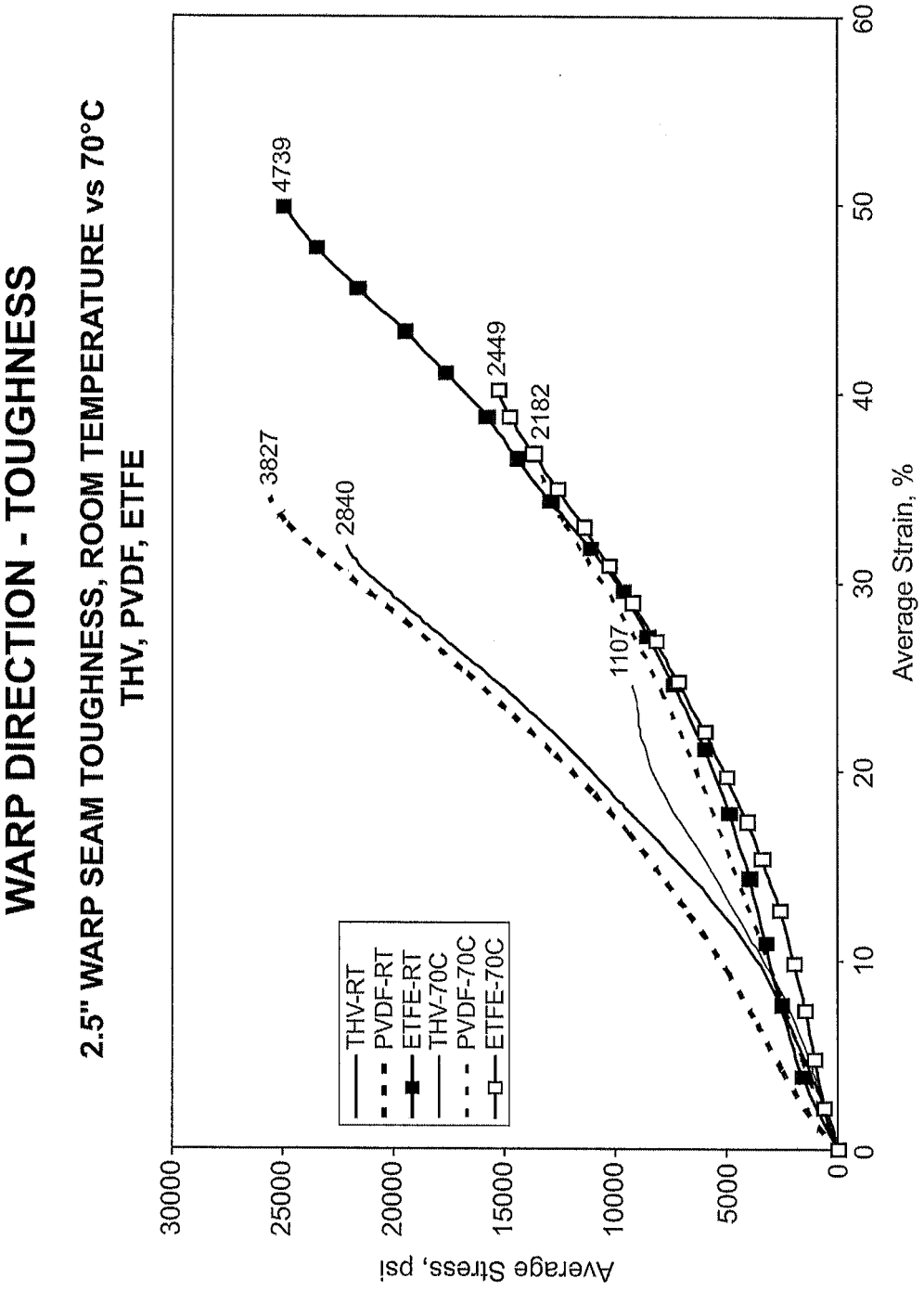

WARP DIRECTION - TOUGHNESS
2.5" WARP SEAM TOUGHNESS, ROOM TEMPERATURE vs 70°C
THV, PVDF, ETFE
Average Stress, psi
Average Strain, %
THV-RT
PVDF-RT
ETFE-RT
THV-70C
PVDF-70C
ETFE-70C
4739
2449
2182
3827
2840
1107
0
5000
10000
15000
20000
25000
30000
0
10
20
30
40
50
60

FIG. 6

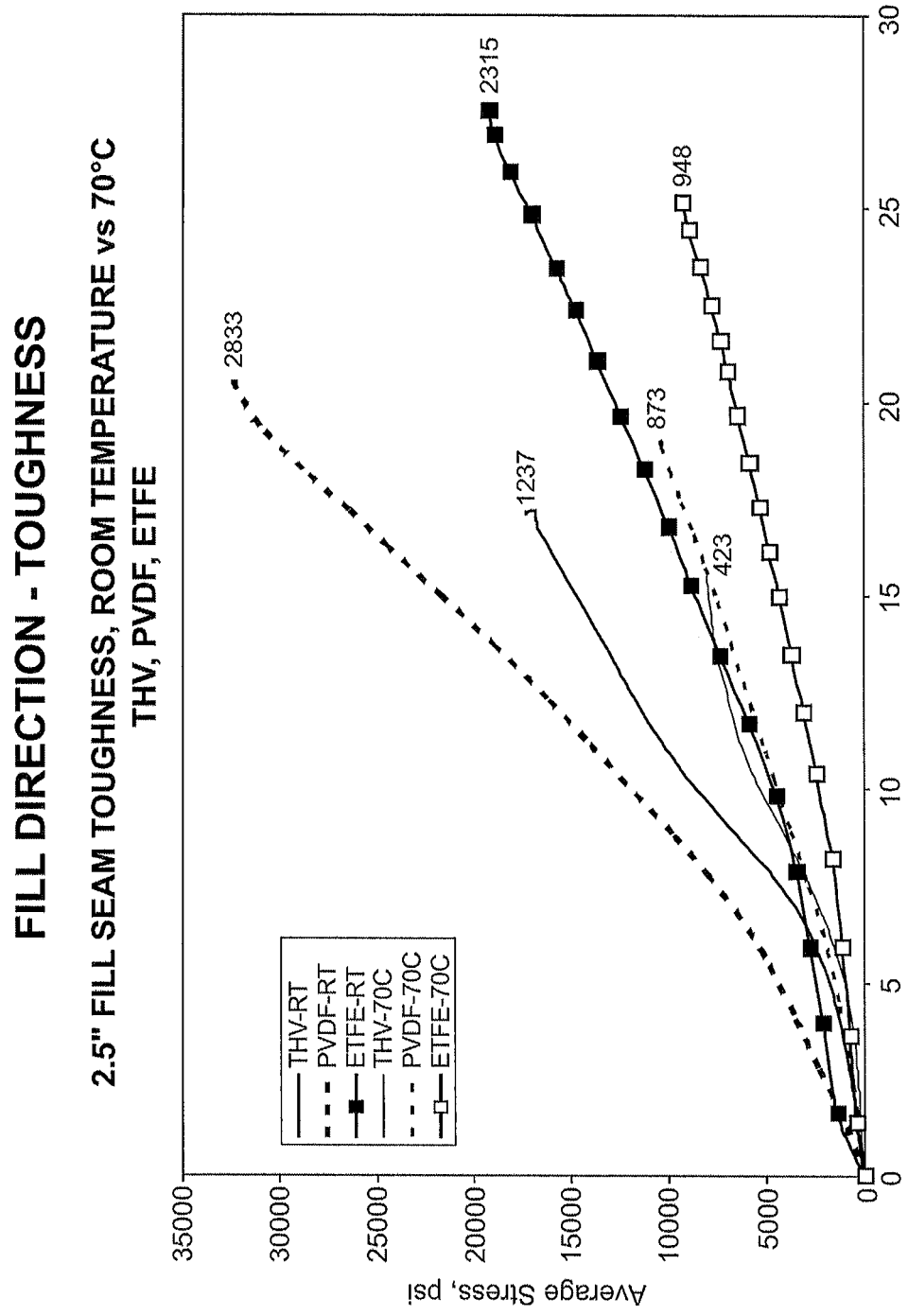

FILL DIRECTION - TOUGHNESS
2.5" FILL SEAM TOUGHNESS, ROOM TEMPERATURE vs 70°C
THV, PVDF, ETFE
THV-RT
PVDF-RT
ETFE-RT
THV-70C
PVDF-70C
ETFE-70C
2833
1237
2315
873
423
948
Average Stress, psi
Average Strain, %
0
5000
10000
15000
20000
25000
30000
35000
0
5
10
15
20
25
30

FIG. 7

REFERENCES CITED IN THE DESCRIPTION

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